

## 6. Debugging Tools

### 6.1 Turbulence Model Diagnostics (DEBUG=1)

An OVERFLOW turbulent quantity debug option is included by specifying the **&GLOBAL** NAMELIST input parameter **DEBUG=1**. Turbulent parameters of interest are written to a “fake Q file” **q.turb**. Familiarity with respective turbulence model quantities is required if meaningful insight is to be expected. Different turbulent quantities are written to the **q.turb** file depending on the turbulence model selected in the OVERFLOW input file.

The file **q.turb** is based on the flow solution input in **q.restart**. The NAMELIST input expected when using **DEBUG=1** is identical to the input required to continue the current OVERFLOW solution using the **RESTART=.TRUE.** option. Note that the **DEBUG=1** option does not take a complete step through the solution, so **NSTEPS** is ignored in the NAMELIST input.

A detailed listing of parameters written to **q.turb** is given in the Tables 6.1-6.6. The row beginning with  $(J,K,LS, \_)$  denotes turbulent quantities stored at the surface, in this case  $L$  is the normal direction. The row beginning with  $(J,K,L, \_)$  denotes turbulent quantities stored throughout the field defined by the **&VISINP** section of the NAMELIST input.

For the Baldwin-Barth and Spalart-Allmaras  $R_T$  models, a turbulence index is returned at the surface in  $Q5$ . This variable ramps from 0 (laminar flow) to 1 (turbulent flow), with a value of -2 indicating invalid data ( $|\omega|=0$ , for example).

When using PLOT3D, it is critical to remember that only grid functions and explicit Q functions are meaningful. The **q.turb** file should be read using:

```
read/unformatted/mgrid/blank/nocheck/x=grid.in/q=q.turb
```

The **/nocheck** option is important, in that without it, PLOT3D will interpret the Q file as containing flow variables, and may modify values to avoid negative density or pressure. Use **/ieee** instead of **/unformatted** for double-precision grid and Q files.

Table 6.1 Debug output for Baldwin-Lomax and Degani-Schiff turbulent quantities (NQT=0 and ITTYP=1).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>
$(J,K,LS, \_)$	$F_{max}$	$y^+$	$ \omega $	$\mu_w$	-
$(J,K,L, \_)$	$F(y)$	$y$	$ \omega $	$\mu_t$	<i>F<sub>max</sub> location</i>
					1 inner
					2 outer
					3 outer wake
					-1 $F_{max}$

Table 6.2 Debug output for Baldwin-Lomax and wake model turbulent quantities (NQT=0 and ITTYP=11).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>
$(J,K,LS, \_)$	$F_{wake}$	$\frac{u_{dif}}{ \omega _{max}}$	$ \omega $	$\mu_t$	$ \omega _{max} location$
$(J,K,L, \_)$	$ \omega _{max}$	$y$	$ \omega $	$\mu_t$	$ \omega _{max} location$
					4 wake
					-1 $ \omega _{max}$

Table 6.3 Debug output for Baldwin-Barth  $R_T$  1-equation model turbulent quantities (NQT=100).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>

$(J,K,LS, \_)$	$c_\mu D_1 D_2$	$y^+$	$ \omega $	$\mu_t$	Turbulence index
$(J,K,L, \_)$	$c_\mu D_1 D_2$	$f_2(y^+)$	$ \omega $	$\mu_t$	Transition factor

Table 6.4 Debug output for Spalart-Allmaras R<sub>T</sub> 1-equation model turbulent quantities (NQT=101,102).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>
$(J,K,LS, \_)$	$f_{vl}$	$y^+$	$ \omega $	$\mu_t$	Turbulence index
$(J,K,L, \_)$	$f_{vl}$	$y$	$ \omega $	$\mu_t$	Trip/Transition factor

Table 6.5 Debug output for k- $\omega$  2-equation model turbulent quantities (NQT=202 or 204).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>
$(J,K,LS, \_)$	$\omega$	$y^+$	$S_{ij}^2$	$\mu_t$	$k$
$(J,K,L, \_)$	$\omega$	$y$	$S_{ij}^2$	$\mu_t$	$k$

Table 6.6 Debug output for SST 2-equation model turbulent quantities (NQT=203 or 205).

<i>PLOT3D Funct</i>	100	160	161	162	163
<i>Q Value</i>	<i>Q1</i>	<i>Q2</i>	<i>Q3</i>	<i>Q4</i>	<i>Q5</i>
$(J,K,LS, \_)$	$\omega$	$y^+$	$F_l$	$\mu_t$	$k$
$(J,K,L, \_)$	$\omega$	$y$	$F_l$	$\mu_t$	$k$

## 6.2 Timestep Diagnostics (DEBUG=2)

A diagnostic “fake Q file” **q.time** can be generated by running OVERFLOW with the **&GLOBAL** input parameter **DEBUG=2**. Running the code with **DEBUG=2** requires the same input files as the **DEBUG=1** option described above. The five field quantities returned in **q.time** are ( $\Delta t$ ,  $CFL_j$ ,  $CFL_k$ ,  $CFL_l$ , and  $CFL_{max}$ ). These correspond to the NAMELIST **&TIMACU** variables **ITIME**, **DT**, **CFLMIN**, and **CFLMAX** specified in the input file.

## 6.3 Residual Diagnostics (DEBUG=3)

A diagnostic “fake Q file” **q.resid** can be generated by running OVERFLOW with the **&GLOBAL** input parameter **DEBUG=3**. Running the code with **DEBUG=3** requires the same input files as the **DEBUG=1** option described above. The five field quantities returned in **q.resid** are the residuals of the five conserved variables.

## 6.4 Solution Adaption Information (DEBUG=4)

A diagnostic “fake Q file” **q.errest** can be generated by running OVERFLOW with the **&GLOBAL** input parameter **DEBUG=4**. The first three field quantities returned in **q.errest** are the error estimation sensor function; the marker array indicating whether the local grid resolution should be coarsened (-1), refined (+1), or maintained (0); and  $\log_{10}$  of the sensor function. Other field quantities are currently not used.